CHANDRA MISSION DESCRIPTION

A.1 Overview

The *Chandra* X-ray Observatory (CXO) was launched on the Space Shuttle Columbia on July 23, 1999. The *Chandra* program is sponsored by NASA's Office of Space Science (OSS) and managed by the NASA Marshall Space Flight Center (MSFC). The prime contractor responsible for developing the spacecraft and integrating the CXO was TRW. The science instruments are:

- The Advanced CCD Imaging Spectrometer (ACIS) – built by the Pennsylvania State University in collaboration with the Massachusetts Institute of Technology (MIT);
- the High Resolution Camera (HRC) – by the Smithsonian Astrophysical Observatory (SAO);
- the Low Energy Transmission Grating (LETG) – by the Scientific Research Organization of the Netherlands (SRON) in collaboration with the Max-Planck-Institut für Extraterristriche Physik (MPE); and
- the High Energy Transmission Grating (HETG) – by MIT.

Chandra has as its primary mission the study of the structure and emission properties of astronomical sources of high energy radiation. The scientific objectives of the *Chandra* Mission are to utilize the Observatory to:

- determine the nature of celestial objects from normal stars to quasars;
- understand the nature of physical processes that take place in and between astronomical objects; and
- understand the history and evolution of the universe.

A.2 Science Payload

Chandra is comprised of the spacecraft, the X-ray telescope, and the Science Instrument Module (SIM). The spacecraft provides the power, attitude control, communications, etc. for the telescope and instruments. The X-ray telescope consists of an optical bench, the High Resolution Mirror Assembly (HRMA), an aspect camera system, and two objective transmission gratings, the High Energy Transmission Grating (HETG) and the Low Energy Transmission Grating (LETG). The HRMA is a Wolter Type I, 1.2 m diameter, 10 m focal length, iridium-coated X-ray telescope. At 1.5 keV, >85% of the on-axis, imaged and aspect-corrected X-rays are contained in a circle of diameter ~1.0 arcsecond.

Chandra carries two focal-plane scientific instruments mounted in the SIM, the ACIS and the HRC. The SIM provides three functions: launch lock, translation (to interchange the two focal plane instruments), and focus. Only one of the two focal plane instruments can be placed at the telescope's focus at any time; therefore, simultaneous observations with both focal-plane instruments cannot be accommodated.

The ACIS has two arrays of CCD's, one (ACIS-I) optimized for imaging wide fields (16x16 arcmin) and the other (ACIS-S) optimized as a readout for the HETG transmission grating. One chip of the ACIS-S (S3) can also be used for on-axis (8x8 arcmin) imaging and offers the best energy resolution of the ACIS system.

The HRC is comprised of two microchannel plate imaging detectors, and offers the highest spatial (<0.5 arcsec) and temporal (16 sec) resolutions. The HRC-I is a single microchannel plate and has a field of view of 31x31 arcmin. The HRC-S consists of three contiguous segments, tilted slightly in order to conform to the Rowland circle of the LETG. The background rate is quite different in the two devices, being larger in the HRC-S.

The HETG is optimized for high-resolution spectroscopy over the energy band 0.4-10 keV. Two types of gratings are mounted in the HETG: medium-energy gratings (MEG's) covering the 0.4-5 keV band and high-energy gratings (HEG's) covering the 0.9-10 keV band. The MEG's are mounted behind the annular aperture of the outer two mirror pairs while the HEG's are mounted behind the apertures of the inner two mirror pairs. The two sets of gratings operate simultaneously so that the dispersed axes of the spectra cross at a shallow angle in the focal plane. The ACIS-S is the readout of choice for use with the HETG. The resolving power ($E/\Delta E$) varies from ~800 at 1.5 keV to ~200 at 6 keV.

The LETG is optimized for high-resolution spectroscopy over the energy bandwidth ~0.09-4 keV. The LETG provides resolving power >1000 at 0.1 keV and ~200 at 1.5 keV. The HRC-S is the only detector aboard the Observatory that can fully accommodate the LETG-dispersed spectrum.

Detailed descriptions of all of the instruments are contained in the *Proposer's Observatory Guide* (See Appendix D for information on retrieving this guide). Proposers should refer to that document for additional details before preparing a proposal.

A.3 Operation

The initial *Chandra* operational orbit was achieved by use of Boeing's Inertial Upper Stage and *Chandra's* own propulsion system. Chandra has been approved for a 10 year mission. The orbital period of about 63.5 hours allows for reasonable long uninterrupted observations of up to ~170 ksec before the instruments have to be powered down as the satellite dips into the radiation belts.

The Observatory's solar panels can rotate about an axis perpendicular to the optical axis so that at any time the Observatory can be pointed to any position in the sky except for avoidance regions around the Sun (45 degrees), Moon (6 degrees), and Earth (20 degrees). Note that both the Moon and Earth may be viewed if specially requested and as long as an accurate aspect solution is not required. The high elliptical orbit and the radiation belts that prevent the conduct of observations at low altitudes imply that the preponderance of observations are nearer apogee, where the Earth, as seen from *Chandra*, appears to move only slowly through the sky. As a result, the Earth and its surrounding avoidance region constitute a portion of the sky that will be partially blocked from view, and long, continuous observations in this region (>30 ksec at the center of the region) will be difficult, although shorter observations are possible. The proposer is urged to read the appropriate chapter of the *Proposer's Observatory Guide* to become familiar with all *Chandra* observing constraints and to make use of the observation visualization tool (WWWObsVis found after keying “Proposer” at http://cxc.harvard.edu) to see how these constraints might impact their observations.

A.4 The *Chandra* X-ray Center (CXC)

The CXC is responsible for planning and conducting *Chandra* operations by generating the science timeline including user-imposed as well as the instrument- or satellite-imposed constraints. All telemetry is sent to the Operations Control Center (OCC) in Cambridge, Massachusetts. The CXC Data Systems Group receives and processes the data and generates standard data products for validation and distribution to the Principal Investigator of a specific observation. The CXC also provides and supports certain data analysis software and a permanent archive of the *Chandra* data. Data in the archive are typically available to the public after a one-year proprietary period expires. Calibration data are available immediately. The *Chandra* Director’s Office (CDO) provides limited assistance to observers and will provide additional technical information, as needed, for the preparation of proposals.

A.5 *Chandra* Target Lists

The present *Chandra* observing program consists of Calibration targets; Cycles 1, 2, and 3 GO and GTO targets; TOO; and DDT targets. The target lists are available from the main CXC web page (http://www.cxc.harvard.edu) via the “Target Lists and Scheduling Information” link. More sophisticated access to the *Chandra* Observing Catalog is also provided via the “Target Search Page” and/or the “*Chandra* Search and Retrieval Software (ChaSeR)” accessible from the main CXC page.